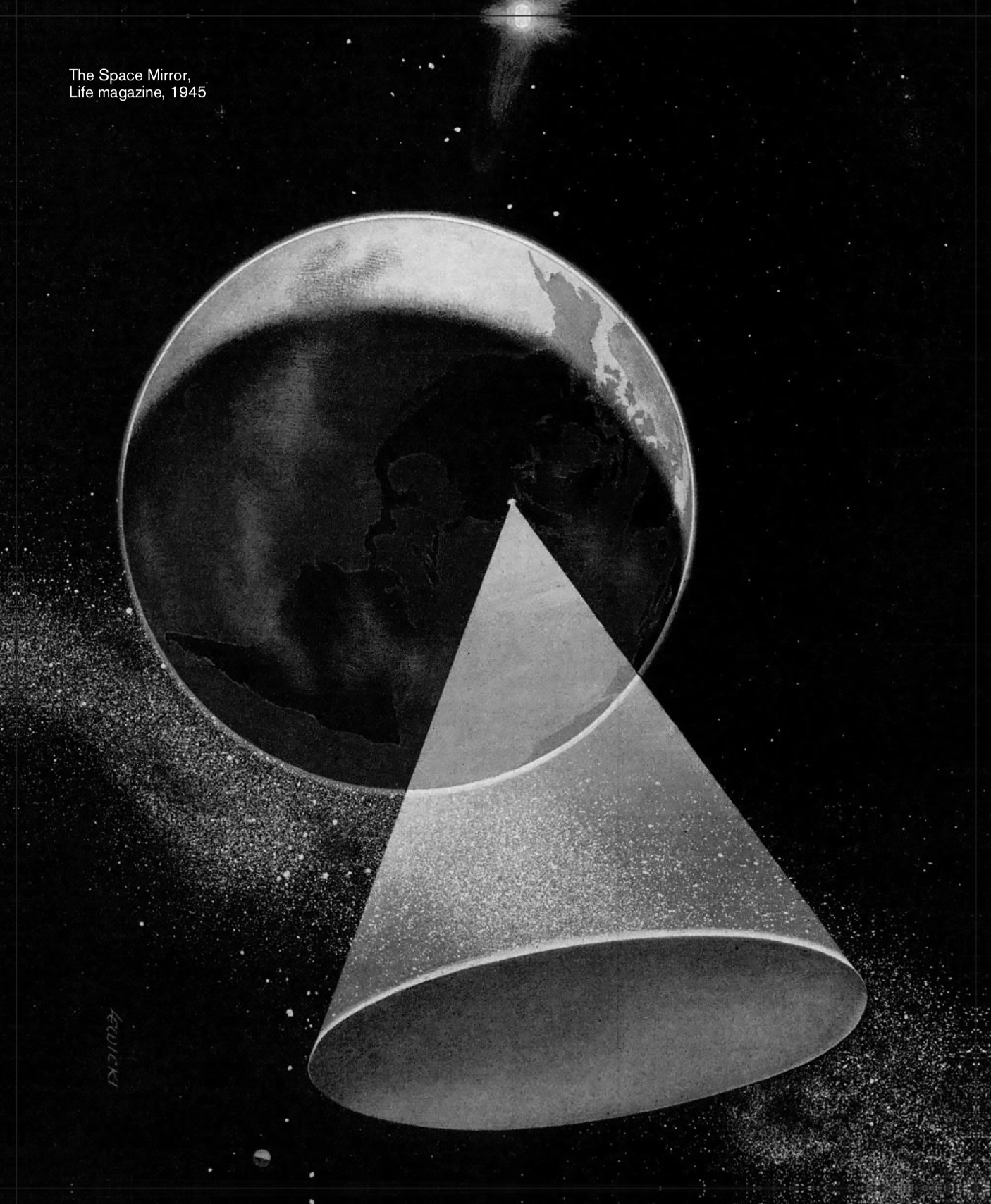
znamya
The Space Reflector


The Space Mirror,
Life magazine, 1945
KUBICKI

Special thanks to my tutor,
Alexandra Midal

To the invaluable help of
Helena Bosch Vidal,
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By Pau Saiz Soler
Tutor: Alexandra Midal
Design: Beatriz Granado & Pau Saiz Soler
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a.

In 1993 Russian engineers launched *znamya-2*, a satellite designed to reflect the light of the sun to illuminate the earth at night. Conceived as part of the Soviet space program,[1] *znamya*'s original plan projected a fleet of satellites that would allow for total control of the lighting of the territory, 24 hours a day. This

project was never fully accomplished.

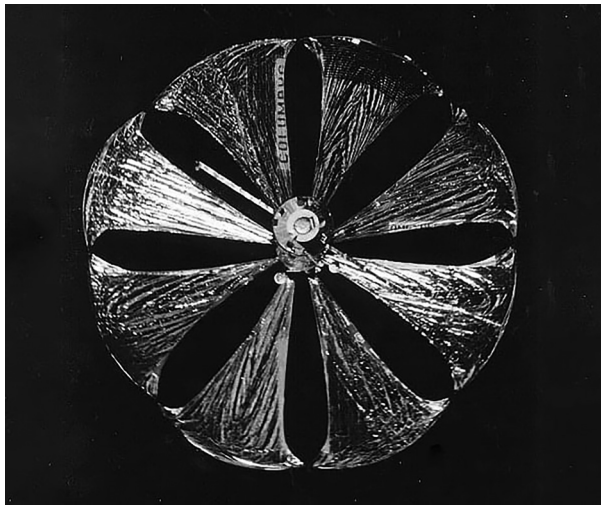
a. Conceptual drawing of the functioning of *znamya*

The *znamya-2* experiment was conducted with the deployment of a twenty-metre thin-film structure aboard the Progress M-15 spacecraft docked to the MIR orbital station. On the 4th of February 1993 the satellite was separated from MIR station to run the test. The part of the satellite which concealed the reflective film started

to spin with the help of an electric motor to deploy the reflector. The reflector itself was made of 8 sectors made of a highly reflective aluminium coated film. The light of the sun was reflected on the satellite to produce a spotlight which traveled through the surface of earth at a speed of 8km per second. It had a diameter of 5 km.

znamya-2 worked but due to cloudy weather on the day of the test, the reflection of light was not strong enough and there was no way to prove that it could become a relevant technology to provide light.[2]

By the time *znamya* was developed, the Space Race[3] was long finished



b. *znamya* satellite on space, photographed from MIR station 1993

and Mikhail Gorbachev, as the head of the Communist Party, was focused on solving the economic crisis. This was the time of Perestroika and Glasnost,[4] when all

efforts were made to prevent the Soviet empire from collapsing. In this context of economic emergency, the difference between *znamya* and other aerospace projects was that this satellite, instead of colonizing space, was earth oriented. *znamya*'s implementation was justified because it could help in the

economic recovery by providing more hours of sunlight as a source of energy. This technology was originally conceived to promote agriculture in Siberia because in winter the sunlight hours are too short for proper growing and harvesting. Although supporting agriculture was its primary stated purpose, engineers were well aware of the many other

potential applications of the satellite. For instance, the satellite could illuminate cities at night and save money on traditional electrical infrastructure, or it could be used to help with rescue tasks after natural disasters. The intention was that the satellites would be remotely controlled from Russia to illuminate specific areas of territory, whether it

was Russian or not. *znamya* was not the first instance in which mankind had thought about making a solar reflector to illuminate the night. Since the beginning of astronautics, several scientists and engineers had theorized about the same ambitious idea. Nevertheless, *znamya* was the only one iteration to be tested in space.

Today, the *znamya* project seems to belong to science fiction more than to history. The testing of the solar reflector has been sort of forgotten, it does not belong to the collective imaginary of space exploration, not even in Russia.[5] Regardless of the reasons for this general amnesia, there seems to be enough information (books,

websites and even videos) to confirm that the satellite existed. At the same time, it is not difficult to imagine some breaking news announcements about how *znamya* had never existed and that everything was an elaborate plan carried out by Russia to scare other nations. I find myself in a position where I can neither confirm or deny if the satellite was real or not.

znamya The Space Reflector, is not an investigation to verify if *znamya* existed or not. My approach to the subject is to examine the relevance of the Russian satellite as the first artificial device designed to provide public lighting from space. To understand in which way

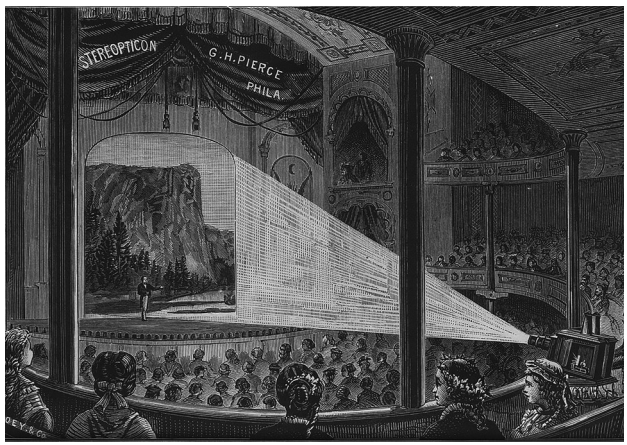
the light of *znamya* could transform the night, I recount the political symbolism of urban lighting, as developed by professor David E. Nye and the author and historian Schivelbusch Wolfgang. Both specialists agree that the organisation of streetlights controls the way citizens perceive the city. The design of public lighting brings

a hierarchy into the streets by deciding what it is shown and what remains covered by the dark. They demonstrate that behind every public lighting design there is a specific ideology. Within this ideological theory of light, *znamya* can be regarded as a totalitarian technology because it centralises the control of public light into one single source.

The artist and Bauhaus professor Laszlo Moholy-Nagy in 1925 had already developed a theory of light as the matrix of art, in which he claimed light not as an auxiliary medium to indicate the existence of something but to be used for its genuine expression due to its qualities. His arguments help us to understand the transformative potential of light and how a city or any other landscape can be conditioned by it.[6]
At night, artificial light captures our attention and sets the narrative of what is visible and what is not. This power of light to capture attention was the same used by magic lanterns (during the 18th and 19th centuries) when the light was projected

in a dark room with an audience.[7] Schivelbusch explained that 'The power of artificial light to create its own reality only reveals itself in darkness. In the dark light is life. The spectator sitting in the dark and looking at illuminated image gives it his whole attention'.[8] Wolfgang was describing here the effect of light-based media from the 19th century such us the magic lantern or the diorama. He claimed that the attention of looking at an image in the dark is connected with the way we can lose ourselves by observing a fire or candlelight. *znamya* is a similar visual experience; it caches our attention by projecting a spotlight that illuminates the territory and creates an

image.
Taking into account
the historical context,
znamya brings
light and produces a
series of images to
reinforce the identity
of Soviet Nationalism.
All the applications



c. The Magic Lantern in the theatre 1880

that the engineers
thought *znamya*
could perform became
images of propaganda.
To understand this
propaganda I follow
the publication of Slava
Gerovitch called “Space
Mythologies” where
the Russian author
explains how the Soviet
government manipulated
the information during
the Space Race period.

Finally, if *znamya*'s light was an expressive medium, projected on earth for propagandistic purposes, the satellite becomes an ideological terraforming technology which hijacks the night. It is terraforming because it artificially modifies the climate of the planet and it is ideological because it seeks to preserve the Soviet and Russian nationalism. Ideological Terraforming is the terminology used to label the ultimate consequence of *znamya*. The idea comes from the Terraforming definition of Benjamin H. Bratton in his book "The Terraforming". The author and researcher at Strelka Institute claim that earth oriented terraforming would be necessary

to maintain the climate
conditions on the planet
to support life.

znamya as Ideological
terraforming opens
an unprecedented
paradigm in which
the light of the sun
it is manipulated as
an artistic medium to
transform the perception
of the territory.

The Film

The movie is a homage to the short period of time on the 4th of February 1993 during which *znamya* illuminated the earth from space. As the light of the satellite travelled through the earth's surface it produced a cinematographic effect. The combination of the light and the movement of the satellite produced a small film. The reflection of sunlight captured the images and, together with the traveling of the satellite spinning around the earth, they performed a motion picture.

The choice of a black and white movie is made with the intention of creating a totalitarian film in the sense that

there is only one colour, one voice to rule the images. Because each colour has its own connotations and brings extra information to the picture, all have to be subjugated into the white in order to equate the totalitarian character of *znamya* as a source of public light. The film is also a homage to the black and white movie Frau in Mond

about the collaboration between the father of the space reflector, Herman Oberth, and the filmmakers Fritz Lang and Thea von Harbou. Oberth, a pioneer of aeronautic theory, was highly influenced by science fiction when developing his ideas. The movie here presented mixes reality and fiction, bringing together historical

facts, the context in which *znamya* was developed, and the influence of space exploration as an idea of national progress.

The first part of the movie is in the form of a documentary and it uses a similar narrative structure as the text. The second part of the movie has a more speculative approach and it imagines a utopic scenario under the light of the satellite.

Some reference is necessary for the second part of the movie: therein appears the building complex of the Presidium of the Academy of Sciences of the USSR (Moscow). A multifunctional complex built between 1960 and the 1990s. The

architecture has more than one influence. Firstly, the vertical volumes are reminiscent of the standard residential blocks of the period. But also, it is the nearest monastery, below the complex which fills the soul of the building: ‘From the outset the authors were inspired by the architectural tradition. The horizontal blocks and vertical monastery ensemble, crowned with golden cupolas, has a response in the layered podium and in the gigantic, closely pressed vertical prisms, crowned with huge gold open-worked cubes’ [9]. The religious inspiration of the complex is mixed with a high-tech look that seems to transfer the building into a science fiction reality.

b.

1.
Lightening the city.

In the old cities of Europe, at night people retreated indoors, blocking and locking everything behind.[10] Every evening, walled cities closed their doors and no one was allowed to enter. In the city, on the streets, night-watchmen carried weapons and a torch with them on their rounds. The city resisted the night, as law and order were incompatible with darkness. Torches were the first tools to provide some illumination in the streets of the city, but their main function was to make their bearers, the citizens, visible. The light worked as identification. For anyone who walked the streets at night, it was obligatory to carry a light, otherwise, they were regarded as suspect and could immediately be arrested.

The candle and the oil lamp were described as "the scaling down of the torch",[11] they were more versatile and easier to use. The candlelight concealed inside a lantern became the first lamps to illuminate the streets. In the capitals of Europe, it extended the perception that a lighted street was a synonym of a safer one. The night city was generally regarded as place for man, unsafe for women. Wealthy individuals could travel in coaches without being exposed to the dangers of the street. With the implementation of public lighting, the night became more accessible to all the citizens, not only because the streets were brighter but also because more people ventured out.[12]

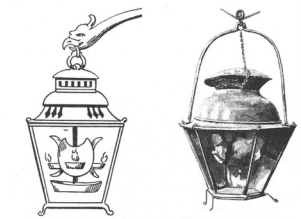
Public lighting started in the sixteenth century when authorities in the larger cities of Europe issued regulations requiring every house to identify itself by displaying a lantern.[13] While this isn't street lighting per se, it can be understood as an extension of the obligation to handle a torch. The lanterns in the houses

helped to identify the city at night and provided order. Through this method, the lights were a pattern for navigating the city but they were not sufficient for full illumination of the streets.[14]

The insufficient streetlight of the city was a popular concern of the time. In 1667, Nicolas Boileau-Despréaux, a French poet and critic wrote: “Le bois le plus funeste et le moins fréquenté / est, au prix de Paris, un lieu de sûreté” (Compared with Paris, the darkest and loneliest forest is a safe retreat).[15] And yet it was precisely the French capital that became a pioneer in public urban lighting. In the same year that Boileau criticized the insecurity of the streets at night, a royal decree implemented a public lighting service under the control of the street police. What had begun as private lighting became a service regulated by the law of the king.[16] The diversity of private lanterns was replaced by a standard lantern, consisting of a candle in a glass box. The glass case was attached to a cable and strung across the street so that they hung exactly over the middle of the roadway. The lamps were like small suns, representing the Sun King[17] on whose orders they had been put up. The lanterns showed who lit the streets and who ruled them. To complete the reform, all medieval shop signs were removed from the facades of buildings to avoid any potential shadows. The city advertisements of different guilds were like multiple voices echoing in the city but the dictatorship of light ranked the power of the monarchy above all others.[18] Public lighting became an extension of the authority of the king.

The new politics in urbanism required new technical improvements. The low intensity of the first lanterns could not properly illuminate the streets. In 1760, Paris implemented the Réverbère, a lantern specifically designed to function on the public street.[19] To increase the illumination produced by the flame, it had a reflector next to each flame to intensify the effect of the light. The result was a bright panoramic

light much stronger than traditional lanterns. At the time, the Réverbère were compared with a small sun and it was considered to be the most powerful light yet invented: “Like the first lanterns one hundred years before, Réverbère were enthusiastically hailed as artificial suns that turned night into day”.[20] But the light of the Réverbère also cast its shadows, the reflection of the flame could not produce a homogeneous illumination and very quickly, critics such as the ones coming from Louis-Sébastien Mercier, found the lights innovative but insufficient.[21]



d. The Réverbère, Paris, mid-eighteenth century

If public lighting was fighting against the chaos and uproar of the city at night, it also suffered the immediate consequences of it by becoming the victim of vandalism. Lantern smashing meant disorder and freedom, and probably the most symbolic act of protest against the power structures established and enforced by the monarchy.[22] During the French Revolution, lanterns were smashed around all the city, not only as a symbol of protest but also to prevent being recognised by the forces of the law. Walking through the city one could identify the area of the riots by how the street lighting diminished until complete dark. During the first days of the revolution, not only were the lanterns destroyed, but the metallic supports used to hold the lanterns were also used to hang any representative of the ancien régime.[23] Once more, the decision of what is seen, and which story is told plays an important role in history. French revolutionaries canceled out the lighting system to perform illegal acts. By that action, they highlighted the power of darkness, above the rule of the

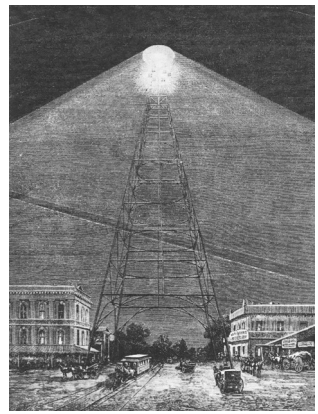
e. English caricature of the French Revolution

light, using the cover of night to empower themselves.

After the collapse of the French monarchy, artificial light remained an element for controlling the streets. The new light regime included the interests of the bourgeoisie and it made all the shops visible even during the night.[24] The memory of the use of lights during the French Revolution and many other revolts on other European capitals didn't stop public lighting from progressing. It radically improved in the 19th century through the introduction of gaslight,[25] which multiplied the illuminative effect of the Réverbère and produced a homogeneous light. The first experiments with electrical light quickly imposed arc light as the brightest solution. Arc-light was first introduced in 1870 and its intensity was compared with daylight.[26] The main inconvenience of arc light was the impossibility of regulating the intensity of the light and its expensive costs, which made it difficult to implement on a grand scale. Arc light was only to be displayed on main roads and squares. One method for maximizing its effect was to raise the source of light as high as possible. The idea of installing a few big lamps to illuminate the entire city started to be considered among entrepreneurs.

Before arc light was invented, Dondey-Durpré designed in 1799 a lighthouse to illuminate the city of Paris. Inspired by the lighthouse of Alexandria, Dondey-Durpré thought of installing several lighthouses at the most important squares of the city, not by chance starting by Place de la Revolution. The lighthouse or light towers would substitute for traditional lanterns.[27] The project never materialized in Paris, but in America, in 1802, some cities like San José, Richmond (Virginia) and Detroit, started to test the installation of metallic towers for illuminating the city. The projects were economically motivated as they were technically cheaper than installing traditional lanterns.[27]8The project in Detroit consisted

of a large scale installation; one hundred and twenty-two towers lit up 54 square kilometers of the city. Each tower was 50 meters high and the distance between them was between 350 to 400 meters at the center of the city and 1000 meters in the outlying districts.[29] The project raised a lot of skepticism and had the citizens divided between supporters and opponents. Brush, the owner of the company leading the project, assured that the lights of the tower would provide a quality light, 'just like first-class moonlight'.[30] The light from the towers was so bright that it kept the animals living in the city awake and after days without sleep, many wound up dead. Also, the direct light cast by the towers produced sharp shadows as soon as something or someone interfered with the direction of the light. This was claimed to be disconcerting for provoking big contrast in the perception of the light.[31] Eventually, the Detroit light towers were discarded.



f. American lighting tower of San Jose, California, 1885

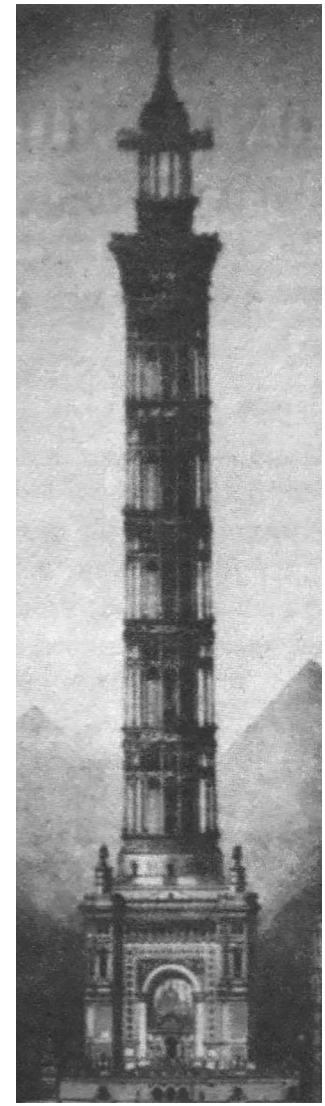
The light towers suggested a new way of organizing the city at night. It is easy to imagine how each tower could determine the arrangement of the buildings in a radial way. In the same way that people gather around the fire, the light towers might have had the potential of organizing the different districts of the city according to the range of their light.

g. A lighting tower standing in the foreground of Detroit's Old City Hall, 1900

For the 1889 Universal Exhibition in Paris the engineer Sébillot, wanted to import the idea of American light towers to the French capital. Sébillot teamed up with the architect Jules

Bourdais to design the Sun Tower, a 360-meter high tower topped with electric light, 'a project to light up Paris from a single source of light'.[32] Apart from its main function of illuminating the city, the tower would also house a museum of electricity, and lifts to bring people up to a viewing platform capable of holding 1,000 visitors. This project attracted lots of attention but it was finally abandoned because of the plan's high cost and danger. Instead, the project selected for the exhibition was the Eiffel Tower.[33]

Despite the technical impossibilities of the Sun Tower, the idea of installing a central light to illuminate the entire city from a single point became very attractive. Even Gustave Eiffel considered putting a light at the top of his tower.[34] The French bourgeoisie were very interested in a light at the top of a tower, a light that could not be smashed, a light to control the population and to prevent all further revolutions. The traumatic experiences of the past, including



h. The Sun Tower, 1885

the French Revolution and later revolts, strikes and riots by the working class, imbued the city with a sense of instability with which artificial light tried to contend. If public lighting has the potential to set up a specific narrative of the city at night, every time a lantern was smashed, it represented an attempt to question and topple the existing power structures.

Since one of the imagined applications of *znamya* was to illuminate cities, in 1993, the satellite became the next step in the evolution of monumental light installations. It followed the same idea of Dondey-Durpré for his lighthouse or the Sun Tower: the centralization of the source of public light.

The centralisation of light becomes a totalitarian strategy in a technological sense precisely because there is only one light left and all citizens are dependent on the same source. Like the monarchy of Sun King, there would only be one voice to rule the streets. On the other hand, public lanterns and the Detroit towers were a more decentralised strategy of illumination, less hierarchical and more democratic. Just as when Louis XIV removed the medieval shop signs, urban transformations are dependent on the politics of public lighting. David E Nye summarises the effect of public light with the following words: "Public lighting, once the perquisite of kings and later a weapon of class warfare, became central to the organization of urban space. It drew attention to a site, defined its contours, increased its importance, and gave it new attributes."[35]

Orbiting in space, *znamya* would be the realization of a long dream of making a second sun. *znamya* would be unreachable for any popular revolution, and therefore it could ensure the continued dominance and authority of the Soviet Empire.

b.

2.
The Space Mirror

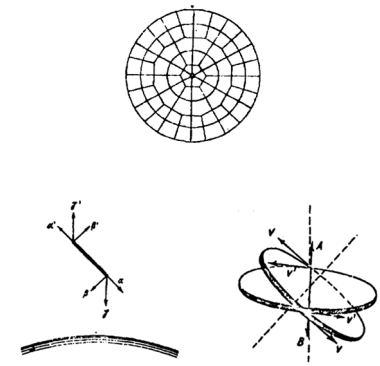
Can *znamya* be considered artificial light since it doesn't produce light, but rather only reflects sunlight? As soon as the rays of sunlight touch the surface of *znamya*, they become part of the satellite mechanism. Sunlight is transformed through the artificial manipulation of its direction and intensity.[36] *znamya* cannot be neatly classified as natural or artificial light; it is the outcome of a combination of a natural source and an artificial intermediary. It represents the subordination of nature to human will.

The idea of manipulating sunlight is much older than *znamya*. It is said that on the siege of Siracusa (213 B.C.) Archimedes already planned to use giant mirrors as a weapon to create a powerful reflection that could burn

the Roman ships. Several texts argue, that the story might be just fiction,[37] but it is also proven that Archimedes was at least developing investigations on light reflections.[38] Despite the burning mirror of Archimedes being more a legend than anything else, it awoke the curiosity of many authors who would later try to develop the same theory.

It was doctor Hermann Oberth who first thought of a precursor project of *znamya*. Oberth, an Austro-Hungarian born in 1894, was considered as one of the fathers of rookery and astronautics. He was the first to dream of a giant mirror in orbit to reflect the light of the sun. In 1929 he wrote the book "Ways of Spaceflight"[39] in which he tried to demonstrate, theoretically, the bases of spaceflight. In chapter 20, (Stations in interplanetary space), he explains how "large scale vehicles can be put in orbit around the earth."[40] Oberth describes the satellite as a 'small moon'[41] and suggests that its reflective effect can be intensified. The

imagination of Oberth brought him not to only imagine a sunlight reflector but a multifunction space station with a docking system for rockets coming from Earth.



i. (top) Organisation of the reflectors for the "Station in interplanetary space", 1929

j. (bottom) Study of the orientation of the "Station in interplanetary space" to reflect the sunlight, 1929

Oberth ideas were highly influenced by science fiction. At the age of 14, he read Jules Verne's "From the Earth to the Moon"[42] and quickly became triggered by the idea of traveling into space. For Oberth, imagining space travels, writing fiction or theorizing about it were very

similar things. In “Ways to spacecraft” he introduces some concepts coming from the novel “The Stone from Moon”, written by the scientist Otto Willi Gail.[43] Because Otto Gail was also a scientist Oberth considered the information from the novel legitimate enough to include it in his academic texts. Gail´s novel is about the adventures of a spaceship that casts a powerful sunlight reflection as a weapon.[44] In 1929, Oberth became Fritz Lang’s scientific adviser for the making of the film Frau in the Moon. The influence of the movie was great, to the point that it became the most popular of the time.[45] Oberth’s thoughts were so connected with science fiction that when he published his book, he dedicated it to Fritz Lang and Thea v. Harbou.[46] It seems that for the father (Oberth) of astronautics, the act of imagining and being able to produce fiction was equally important as the development of scientific theory. Indeed, both disciplines had a notable influence in shaping the beginning of astronautics.

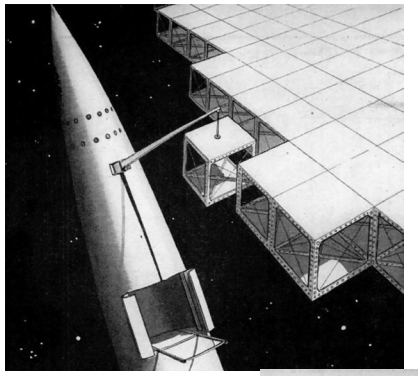
Science is also responsible for the creation of its own mythology in the form of science fiction.[47] The idea for a space mirror came from the dreams of the pioneers of aeronautics, transitioning from science fiction projection to eventual reality. Oberth projected his ideas into space, creating a constellation of technologies and artifacts for space travel and colonizing new worlds. For Oberth, imagination was the light that allowed him to foresee new worlds.

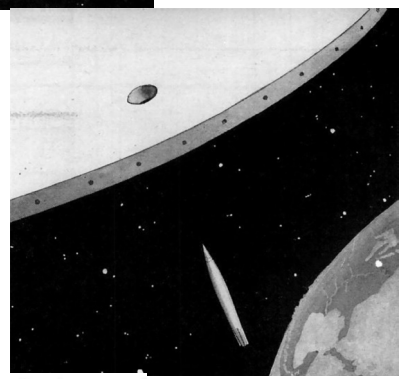
In ‘Ways to Spaceflight’, the orbiting satellite was not given any specific name rather than the above-mentioned “Station in interplanetary space”. In the book, the satellite was thought of as a multifunction platform, starting with communication, for sending light signals to Earth, allowing for telegraphic communication, sending messages during the war, navigation, expeditions, or contact with isolated areas. Another application would be to use the satellite as an observatory; it could take pictures of any territory[48] and spot any natural incident to

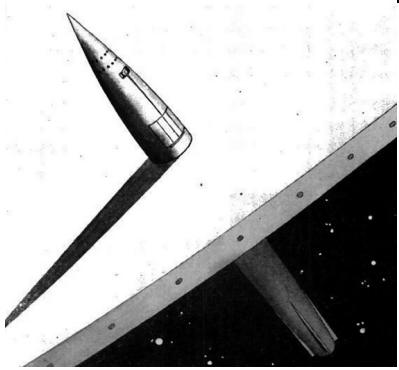
prevent natural disasters.[49] Oberth describes several applications for the satellite, including the use of sunlight reflection for the melting of icebergs, and the creation of clouds by evaporating the sea. The reflection of sunlight was also intended to provide illumination during the night, as Oberth imagined "a provider of sunlight on demand". Because of concerns about the possible environmental consequences of applying too much light to Earth, Oberth restricted the use of reflected light to cities in the southern hemisphere.[50] This collection of possible applications for the satellite also made it clear that the satellite could also be seen as a potential ultimate weapon.

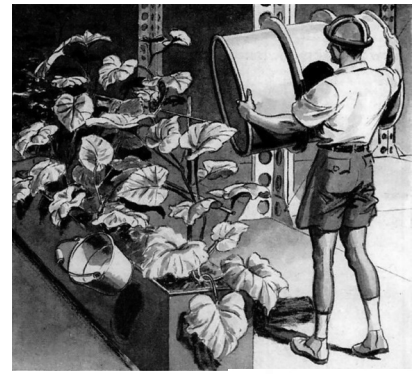
Oberth was open in his support of the use of weapons: "In my opinion, war can be prevented only by creating weapons which the public respects and with which it does not wish to become acquainted."[51] In fact, he already described his satellite as the ultimate weapon. In 1940 he became a German citizen and worked along with the German army during the Second World War. He helped to develop the V-2 rocket.[52] The Space Mirror and its potential application caught the attention of the Nazis. An article in Life magazine from 1945 reported that the US army found German plans to launch what they called a Sun-Gun: "a space mirror that could burn cities to ashes and boil seas to destroy the enemy's fleet."[53] The article includes pictures of the mirror, with drawings of the construction and the proposed functions.

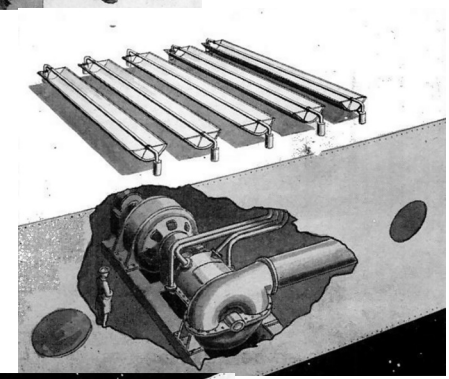
Following the work of Oberth and the Nazi scientists, American scientists pursued their own studies on the development of a space mirror. The first was the scientist A. G. Buckingham who studied how to develop a solar reflector, once more for military purposes, during 1967 and 1968.[54] At the time, Buckingham was interested in its potential application in the war (1954 -1975) between the USA and Communist North Vietnam.[55] The US Army had sufficient technology to manufacture

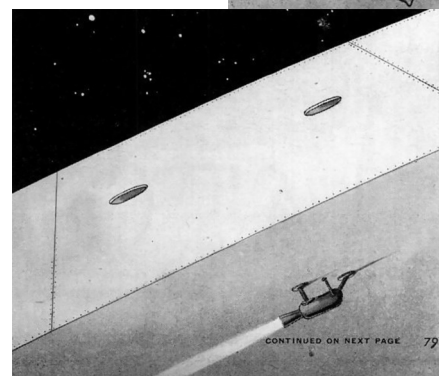










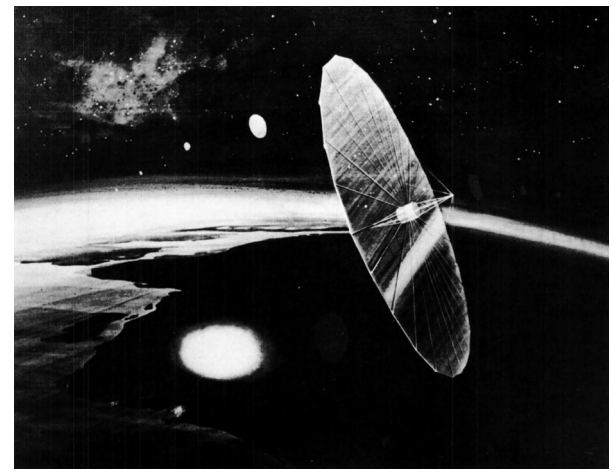


k; l; m; (left) n; o; p. (right)
The space Mirror,
Life magazine, 1945

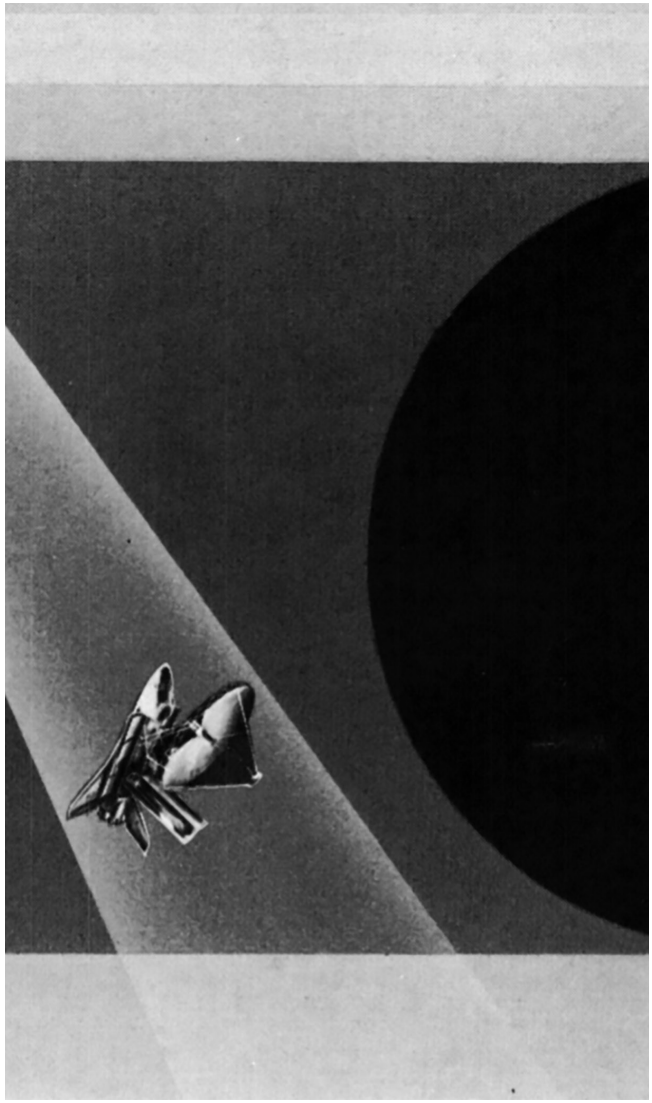
a 250-foot diameter mirror with support from NASA and the Air Force. However, the project was eventually canceled due to the end of the war. In 1970, the German rocket-propulsion engineer Krafft A. Ehricke studied the potential applications of the space mirror on his papers "space light."[56] Ehricke was a devoted promoter of space colonization as he himself developed the concept of "Extraterrestrial Imperative."[57] His studies on the space mirror include several applications: providing illumination, space farming, generating electric power or climate control.[58]

One of the last and most relevant papers came from NASA at the hands of two scientists: John E Candy Jr and John L. Allen Jr., dated from 1982.[59] The document references all the previous research by Buckingham and Ehricke but updated to reflect developments in the relevant technology. It provided new calculations, tables, and diagrams to show the possible functioning of the satellite. Unlike the previous examples, in this case, the paper approached the idea of a space mirror only as a peaceful light reflector. It was intended to illuminate large urban areas and to light other in-orbit satellites and their night operations. It could also work as illumination for emergency operations and farming competences including photosynthesis.

This last approach led by John E Candy Jr and John L. Allen Jr. set the theoretical framework to allow the construction of *znamya*. In both cases, the satellite was thought only as a



q. Artist's conception of solar-reflector spacecraft



r. Illumination of Shuttle in-orbit operations 1982

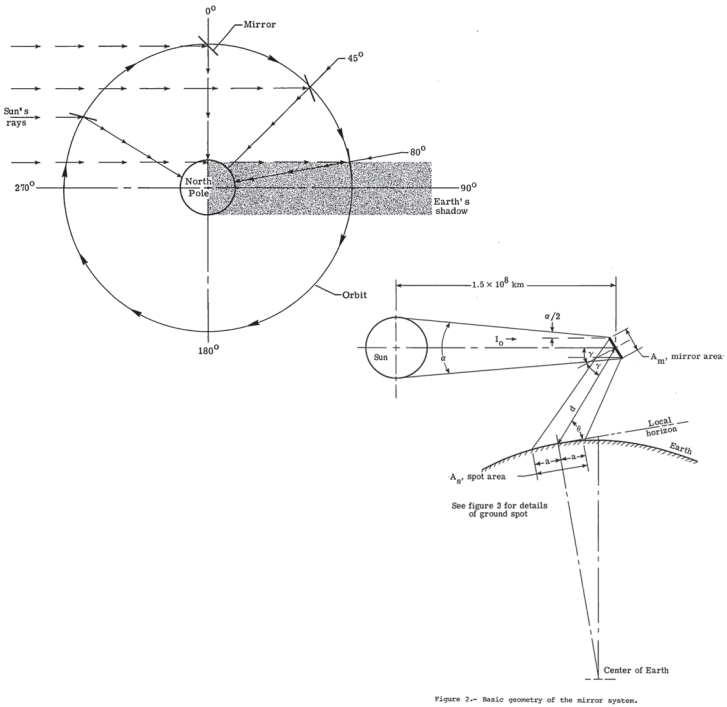
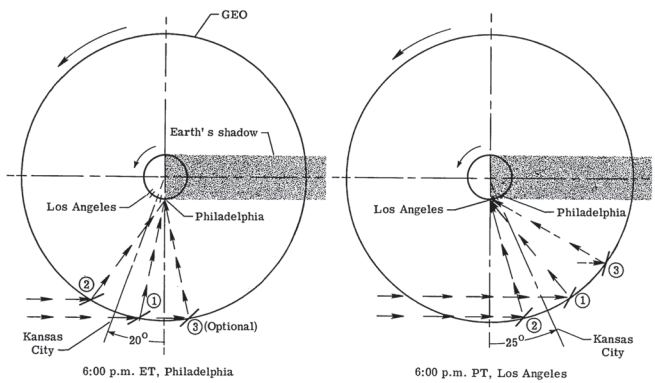
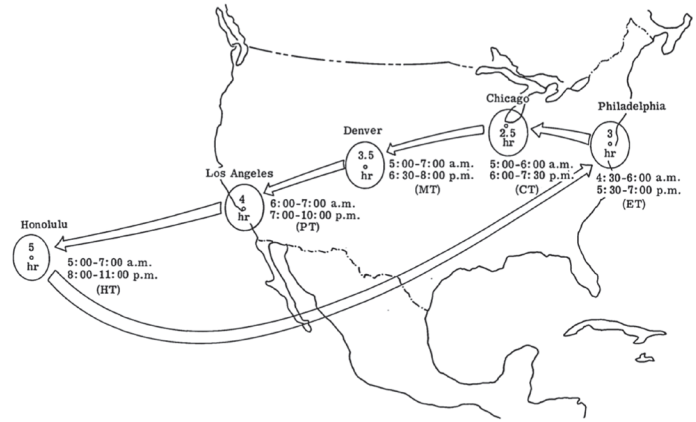
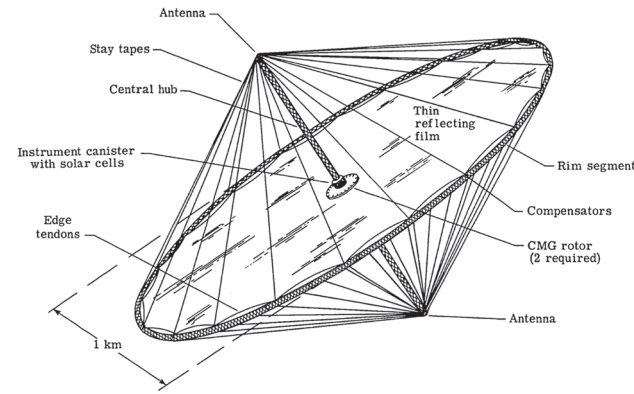


Figure 2.- Basic geometry of the mirror system.







s; t; u. (left)
Space mirror orientation, 1982
Basic geometry of the mirror system, 1982
Scenario extending daylight in the cities, 1982

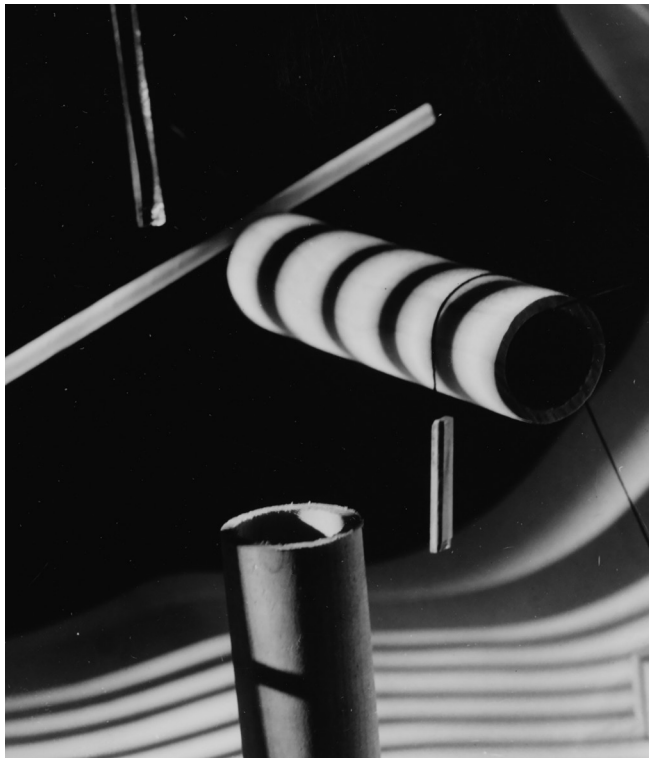
v; w. (right)
Scenario for extending daylight hours across country 1982
Hoop-column solar-reflector spacecraft concept, 1982

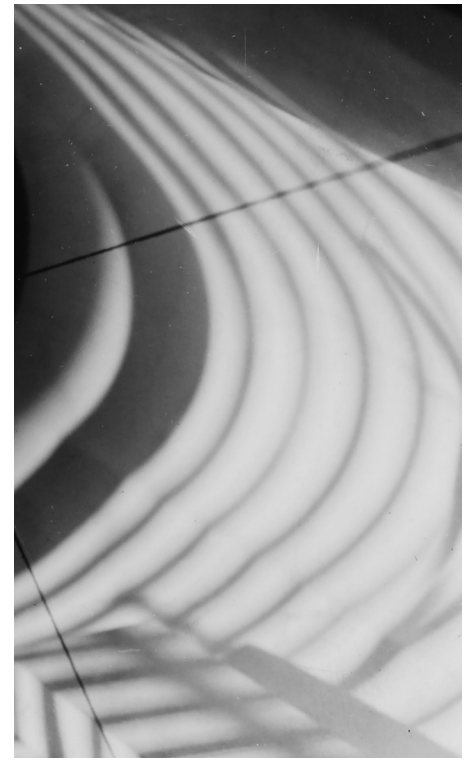
reflective screen and not as a space station.
There is a big difference between illuminating from space and the traditional city lights: The city lanterns were attached to the ground, illuminating the same place where they were placed, the streets, but the satellite is not placed in the city, the source of light it is decontextualised from the territory and it belongs to another world: space. Set as the tallest light it would represent the maximum authority within the hierarchy of public lighting. At the same time, the satellite it is not just a monumental source of illumination but a new bridge between the natural world and the artificial one. The reflection from *znamya* is a sort of alchemy that synthesis the two worlds. Like the spotlight on the stage of the theatre, the sunlight reflection it would induce a fascinating, almost magical view of the reality.[60]

Impressionists painters used colours to represent light as an attempt to reproduce the effect of light on the landscape.[61] This observation made by Laszlo Moholy-Nagy reveals the expressive potential of light. Moholy-Nagy developed a theory of the light as an artistic medium which can help to understand *znamya* as a lighting artefact: He considered light as one of the elemental factors in art creation to comprehend and conquest space.[62] On his book, The New Vision, Moholy-Nagy Quotes Nathan Lerner, one of his students at the Bauhaus (Chicago): "Usually light was not considered as plastic means, only as an auxiliary medium to indicate material existence. Now a new period starts where light will be used as a genuine means of expression because of its own qualities, own characteristics." Moholy-Nagy differentiated between two ways of creative manipulation of light: Light displays in the open air and indoor ones. For the open-air Moholy-Nagy talks of "the night life of a big city as a new field of expression" and describes how the artist could play a key role in the set up of the reflectors and neon tubes of advertising signs, the blinking letters of storefronts, the

use of gigantic searchlights and sky-writers, projections on to clouds or on to other gaseous backgrounds, etc.[63]

Fully aware of the educational and formative ideological function of art, Moholy-Nagy claimed the political connotation of every artistic intervention, including the manipulation of light.[64] Through the optics of art-light theory, *znamya* can work as a gigantic installation which inevitably transforms ecstatically and ideologically the territory.





x. N. Lerner, Light volume study, 1937

b.

3.
znamya

"We had made it
to the stars and,
as the saying went,
"there was no bearded
old God there."
Only science. Only
the Soviet system."[65]

znamya (Знамя) was the name of the Russian project that developed the space mirror. The name translates to English as a banner or flag. The project lasted from 1990 to 1999, and during that time two prototypes (*znamya-2*

and *znamya-2.5*) were sent to space.[66] This was the only historical attempt to build the space mirror but shortly after the failure of the second prototype the project was abandoned. Therefore, *znamya* was never practically used. To understand what triggered the project and why it was finally abandoned, it is necessary to study the immediate context in which *znamya* was developed, as well as the legacy of the Space Race which took place some years before and profoundly influenced the character of Soviet Nationalism.

By the 1950s, the Soviet Union was deeply enmeshed in the Cold War against the United States.[67] One of the most relevant moments of the conflict was the so-called Kitchen Debate in 1959, which unchained an ideological discussion between the presidents of the two respective countries Richard Nixon (USA) and Nikita Khrushchev (USSR). It was in the American National Exhibition at Moscow, when President Nixon presented the catalyst USA model by exhibiting several domestic commodities which highlighted their benefits compared to the Communist collectivist convictions.[68] To fight back against this American propaganda, the USSR showed its advanced space technology by putting into orbit the first satellite (Sputnik) in 1957. Sputnik triggered what was called the Space Race,[69] which consisted of a series of actions during the following years, through which the USSR and the USA competed to conquer space. In the beginning, the Soviets were leading the contest thanks to several achievements, including the first manned mission to space. In 1969 the Americans put an end to the dispute by completing the first successful manned mission to the moon.

For the Soviets, the cosmos represented the promise of a better future. All progress made in aeronautics played a worldwide empowering role for the Soviet Empire. The achievements in aeronautics not only proved the technological

superiority of the USSR but also played an important ideological role by promoting Soviet Nationalism. As Sasha Rospopina, writer for the Calvert Journal[70] formulates "The cult of science and space exploration in the Soviet Union was as close as to religion for an atheist state-the space program was presented as the result of the great work of the proletarian."[71] The cosmos imaginary invaded all areas of the soviet society and culture, influencing art design and architecture. While the Soviet administration was in charge of space propaganda, the population of the USSR was simultaneously promoting the cosmos imaginary, not always as part of a belief in their communist country but also as a form of escapism from the oppression and difficult conditions that they were experiencing.[72]

The official history of the soviet space program and the private interpretations developed by individuals configured a complex mythology for the Russian society. Even after the downfall of the USSR, the achievements of the space race became part of the national heritage for the newborn Russia.[73] "If we did not have Gagarin, we would not have been able to look into each other's eyes. It seems we blew everything we could. But we still have Gagarin. We will never lose him (...) Gagarin is the symbol of a Russian victory over the entire world, a symbol for ages to come. We don't have another one and maybe never will. Gagarin is our national idea."[74]

y. Monument in honor of Yuri Gagarin 1980

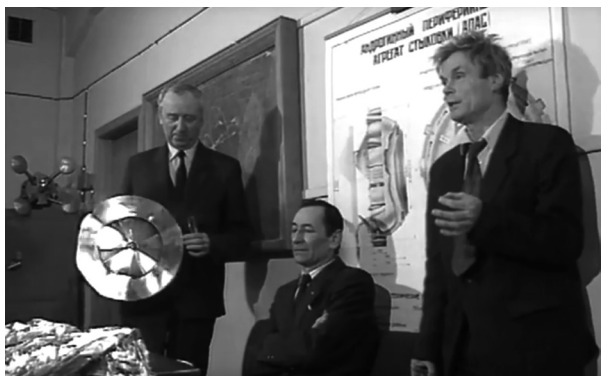
By 1980, after the fever of the Space Race, the Soviet Union stopped the majority of their space projects. By the end of the 1980s, the Soviet Union was on the brink of collapse which among other consequences, would also mean the end of their cult of science and space exploration.[75] In a desperate attempt to save the economy of the USSR, President Michael Gorbachev implemented in 1985 a plan named Perestroika. The project was a series of measures such as to privatisation of farms, greater industrial efficiency, and reduced imports. In order to gain sufficient popular support and be able to implement Perestroika, Gorbachev was advised to relax governmental control and filtration of information and concede some individual rights and freedom to the USSR citizens. These concessions came in the name of Glasnost, with the goal of providing more transparency within the communist state and giving Gorbachev enough credibility to implement Perestroika. Glasnost turned out to be an opportunity to empower the minorities in the URRS and consequently to overthrow the political supremacy of Moscow. Glasnost became one of the reasons for the Soviet downfall.[76]

In this time of economic and political struggle, the project of *znamya* was born. Though the Space Race was long gone, the construction of the satellite could be justified because of its potential to improve the economy[77] and empower the Soviet Administration.

The program *znamya* was instigated by Columbus 500, an international contest set by the United States in 1988. The contest was focused on designing spaceships powered by solar sailing. (By this time, relations between USA and the USSR had relaxed and in fact, both countries were collaborating on the Soyuz Apollo program). The contest aimed to select three projects from the participants to commemorate the discovery of America by Christopher Columbus 500 years before.

Vladimir Syromyatnikov, the leader of the Russian team, assembled a group of scientists and engineers coming from EPO Energia, the organization responsible for the development of Sputnik.[78]

Columbus 500 was never realized due to a lack of funds. Regardless, Syromyatnikov and the other members of the team created a subgroup within the EPO Energia to redirect their project and develop, finally, the space mirror. The Space Regata Consortium was the name of the team of professionals led by Syromyatnikov. At that time, the team of experts proposed a constellation of 100 reflectors, each 1,300 feet in diameter with a surface area of 30 acres.[79]



z. Image: Vladimir Syromyatnikov (Right) and two teamates 1993

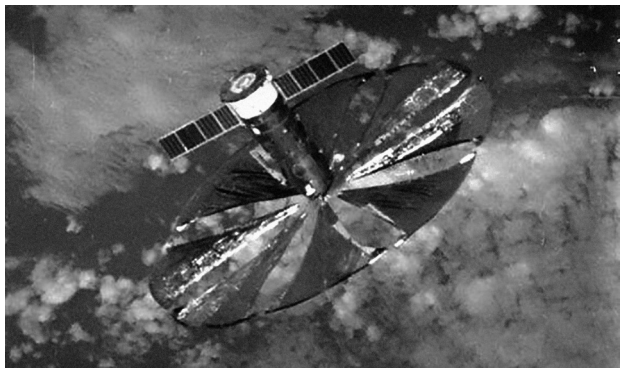
It is difficult to discern the true interests of the administration regarding the production of *znamya* and the technological developments it represented. What is known is that the Russian government agreed to the project and provided the necessary infrastructures to tests the prototypes.

znamya-2

The first illumination from space took place on February 4th, 1993. *znamya-2* was launched from MIR station.[80] The satellite incorporated a circular 20-meter mirror to reflect the light of the sun. The mirror itself was a frameless thin film of plastic-coated in aluminum.[81] To display the film into space, the scientists used the natural forces of inertia, a solution that seemed appropriate for the conditions of airless space and weightlessness. With the help of an electric motor, the satellite initiated the rotation to start displaying the mylar membrane. The impulse

of its constant rotation not only allowed the extension of the reflector but also maintained a strong center from which the satellite could keep spinning and keep the same orientation.

After being ejected, the satellite started to spin and deploy the reflective film. The film was divided into eight segments that together formed a disc. (The division of the disc into



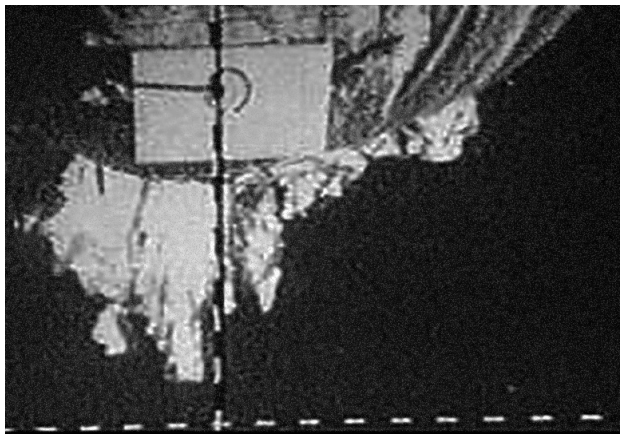
a1. *znamya-2* 1993

segments was the only way the scientists knew to correctly open the film). The film was not completely stretched out, though the spinning movement worked to deploy the mirror, the design of the eight segments didn't completely succeed. Nevertheless, *znamya-2* managed to reflect the light of the sun back to earth and it did illuminate Europe. A light spot reflected by a reflector measuring about 5 kilometres glided across the Earth at a speed of about 8 km/sec crossing the southern France, passing over Toulouse, through Switzerland over Bern, through Southern Germany, between Stuttgart and Munich, Czechoslovakia, Poland, and it dissolved within the rays of the rising sun over Belarus. The weather that morning was not favorable for the experiment; Europe was under heavy cloud cover. However, many people from different areas reported a flashlight from space.[82]

The weak reflection of the satellite the result was not fully convincing for the scientists that created it. However, it had the media's attention and the Space Regata Consortium[83] gained enough credibility to get more funding for a second test.

Znamya-2.5

Znamya-2.5 experiment was carried out on the anniversary of *Znamya-2*, February 4th, 1999. This satellite carried a bigger mirror satellite with a remote control to redirect the axis. Unfortunately, the spacecraft control software transferred onboard from Earth had no command to close the antenna previously open. Due to technical mistakes, the antenna broke the reflective film bringing a premature end to the test.



b1. *znamya-2,5* 1999

After the total failure of *znamya-2.5* the Space Regatta Consortium couldn't develop any more tests and the program was abandoned.

In the same way, as public lights illuminate the city or the magic lantern from the origins of cinema, the light of *znamya* eliminates the neutrality of the night lighting a particular point of the landscape and making it visible while the rest remains dark. Artificial light is a tool to manipulate attention because light concentrates it on a chosen point. The cinema and theatre use the same method; a black room is needed to see the screen or the stage, in order to tell a story. As a consequence of the manipulation of the attention into the highlighted scene, artificial lighting generates an image that is exposed to the eye, directing the perception to a collection of deliberately chosen frames. The sequence of decided images is what configures a narration of what is, or has been shown *znamya* then becomes a producer of images, projected on the surface of the Earth, which functioned as

a screen. The satellite uses the night as a dark space that enables it to decide where things are happening, where we should look, or exactly the opposite, where should we not.
Slava Gerovitch explains how recent research in cognitive neuroscience indicates how "Our memory is much more dynamic and malleable process than previously thought[84]." Memories are not unalterable, they can be manipulated and reconstructed into new ones. The idealisation of the space exploration in Soviet Society mixed true facts and fake ones, making difficult to discern the veracity of each history.[85]

The Space Mirror is halfway between reality and science fiction. *znamya* was the first real attempt to prove its viability but the experiment did not succeed. Today, *znamya* has become a kind of forgotten experiment and it is already difficult to tell if the satellite really existed or not, it just seems unreal.

Ideological Terraforming

Terraforming is the action of transforming a hostile planetary environment into one that is Earth-like so it can host live. It is a strategy for space conquest through the colonization of new planets. Several authors have published some works regarding the subject, considering the terraforming capabilities of planets such as Mars or Venus.[86] Terraforming on other planets has never been implemented but only developed as a theory. On the other hand, there are authors who talk of earth oriented terraforming where the conditions of our own planet are altered.[87] Extraterrestrial terraforming and earth oriented are both an answer to deal with the heritage of the Anthropocene and its looming ecological consequences.

Earth oriented Terraforming is not new and has already been implemented as Benjamin H. Bratton explains how urbanism has historically transformed the surface of Earth.[88] *znamya*

becomes a terraforming technology because it changes the climatology of the planet by transforming night into day. *znamya* brings light to different parts of the territory according to what is convenient to show. For instance, to Illuminate the wheat fields in Kazakhstan, it not only provides more hours of light to make the crops grow faster but it also gives an image of how prosperous the agriculture of the country is, and how much the government cares for it.[89]

1. To provide illumination for agriculture in remote geographical areas with long polar nights in Siberia and western Russia.

2. To illuminate cities and save electrical lighting costs.

3. To allow more working hours on large construction projects.

4. To help in rescue and recovery operations after natural disasters like earthquakes and hurricanes.

5. For military purposes. [90]

There is not an official list of all the applications *znamya* was thought for. Different newspapers covered the events of the time and reported some of them:[91]

Each of these applications not only has a direct impact on the territory but they also transcend into an image of what the government cares for. Anyone under the light of *znamya* becomes a sort of national hero, representing their country on the path to progress. The “heroes” become the testimony of what is the light of the satellite showing and passing on the message among the other citizens. Audiovisual platforms such us TV, or radiophonic transmission would have also covered the progress of *znamya* to the most isolated places in the country. The light of *znamya* becomes propaganda, to ideologically terraform the earth.

5.

The space reflector is probably one of the most astonishing examples of aeronautics technology that mankind has developed. First theorised by Herman Oberth, it belongs to the primitive imagination of space exploration and is very much influenced by science fiction. Through the years different teams of scientists and engineers

have been interested in the technology and today the satellite remains relevant as a terraforming solution.

Given all the studies developed around the space reflector, it is surprising that *znamya* has been the only one yet tested. The Russian project is the only one publicly accounted, and *znamya-2* became the

first satellite to illuminate the earth from space.

Though *znamya-2* only projected a spotlight of 5km, more satellites or bigger ones could have easily illuminated entire cities. The light reflected from *znamya* could be remotely controlled to be projected on any territory. Because the light of *znamya* is a source of public light,

it has the power to organise the city and establish a hierarchy according to a specific political message. As a technology, the light of *znamya* has a totalitarian character because its spotlight centralises the source of light into a single one.

Put into practice, in the interests of the USSR and Russia, *znamya* became propaganda to reinforce the nationalism of the country. As it happened during the space race, the simple act of putting into orbit the satellite can alone be considered as propaganda but the most relevant fact is the capacity of the satellite to illuminate the territory and create images out of the night. The light of the satellite

was a medium to
picture different scenes:
prosperous agriculture,
new and sophisticated
architectures, etc.

We can recall how
among the touristic
souvenirs, a postcard
used to be one of the
most popular gifts.
A postcard frames
an image of a place
or something visited

but never seen in the
same conditions as the
postcard shows it: the
picture of the postcard
represents an idealised
representation of what it
shows. *znamya* plays
the same trick: its light
framed one specific
area, deliberately
chosen to picture the
territory and show one
specific scenario as
national propaganda.

Laszlo Moholy-Nagy's theory of light helps us to understand how light has an expressive quality on its own, this means that it can transform the surface where it is projected and determine the character of it. The light of *znamya* "paints" the night and changes the perception of it.

d.

1. Znamya (Знамя) was the name for a series of satellites tested during the 1990s. The name translares to banner or flag. The project started in 1989, before the collapse of the Soviet Union and it survied the political transition to eventually be tested in 1993 (Znamya 2) and in 1999 (Znamya 2.5).

2. The test of Znamya 2 is described by the leader of the project Vladimir Syromyatnikov on his memories. In: Сыромятников, В. С. 100 Рассказов о Стыковке и о Других Приключениях в Космосе и На Земле. Москва: Логос, 2010. P 283

3. The Space Race was the competition started in the late 1950s between the USSR and the United States to develop the most advanced technology for space travel. It is considered another chapter of the Cold War between the two countries, “in which each side sought to prove the superiority of its technology, its military firepower and–by extension–its political-economic system”. In: History.com. A&E Television Networks, *The Space Race.* February 22, 2010. https://www.history.com/topics/cold-war/space-race.

4. Perestroika and Glasnost were two different strategies to restructure the russian economy. The first one was directly aimed to promote economic measures “that would privatise farms, make industries more efficient, and trim down imports, which at the time vastly outweighed exports”. While the second one seek “to signify openness in public affairs, press, politics, education, and even free speech”. In: Powell, Nick. *The Effect of Glasnost on the Dissolution of the Soviet Union,* June 29, 2011, 1–15. Accessed August 4, 2019. http://wordscapes.com/nick/bio/TCR_22_3_Spr_POWELL.pdf..

5. The first satellite Sputnik, the first man on space, Yuri Gagarin, or the First man on the moon are some of the historical events that belong to the collective imaginary of what space exploration has achieved. Znamya is not accounted among them.

6. Laszlo Moholy-Nagy developed his theory of Light as an expressive medium in his books: *Painting, Photography, Film* (1925) and *The New Vision* (1928).

7. The magic lantern was a device that combined a spotlight (originally candlelight or gaslight) with a painted image on a piece of glass. As a result it projected an amplified version of the image from the glass.

8. Schivelbusch, Wolfgang. *Disenchanted Night: The Industrialization of Light in the Nineteenth Century*. Berkeley: University of California Press, 1995 p. 221

9. Râbušin Aleksandr Vasil′evic., Smolina Nadezda Ivanovna., and Vieri Quilici. *Landmarks of Soviet Architecture: 1917-1991.* New York: Rizzoli, 1992. p 150

10. In Hamburg, the gates were still being locked at the end of the eighteenth century. Wolfgang Nahrstedt writes, 'Closing the gates severed the link with outside' In: Nahrstedt, Wolfgang, and Wolfgang Nahrstedt. *Die Entstehung Der Freizeit: Dargestellt Am Beispiel Hamburgs: Ein Beitrag Zur Strukturgeschichte Und Zur Strukturgeschichtlichen Grundlegung Der Freitzeitpädagogik.* Göttingen: Vandenhoeck & Ruprecht, 1972. 1972, p. 88.

11. Schivelbusch, Wolfgang. Op. cit. p. 5

12. Nye, David E. *American Illuminations: Urban Lighting, 1800-1920.* Cambridge, MA: The MIT Press, 2018. P 212

13. Schivelbusch, Wolfgang. Op. cit. p. 82

14. Ibid p. 82

15. A. and W. Galignani, *The History of Paris from the Earliest Period to the Present Day: Containing a Description of Its Antiquities, Public Buildings, Civil, Religious, Scientific, and Commercial Institutions.* Paris, 1832. Chapter XIII, p195.

16. Schivelbusch, Wolfgang. Op. cit. p. 84

17. Louis XIV (1638-1715), king of France (1643-1715), was known as the Sun King.

18. Schivelbusch, Wolfgang. Op. cit. p. 84.

19. The Réverbère was designed in 1760 in a public contest to illuminate the city of Paris. The original idea was from the chemist Lavoisier, though the model implement was slightly different In: Schivelbusch, Wolfgang. Op. cit. p 93.

20. Herlaut (Commandant), *L'Eclairage des rues a Paris.* Paris, 1916. p. 252.

21. Mercier, Louis-Sebastien. Tableau de Paris. Forgotten Books, 2017. Vol. 1, p. 212.

22. Herlaut (Commandant), Op. cit. p. 226

23. Ibid p. 18.

24. Poncet de Cluny, *Progres medical XX.* 1880, p. 627.

25. Schivelbusch, Wolfgang. Op. Cit., p. 115

26. Arc light is different from the incandescent light used nowadays. The main difference compared with the bulbs later invented by Edison is that its light directly emanated from white-hot electrodes instead of the traditional filament of the bulbs.

27. Dondey-Dupre, Projet ..., Paris, 1799. p. 4.

28. Illuminating a city with the use of lanterns required the installation of multitude of lights, which increased the hiring time of the workers and made the process more expensive In: Fred H. Whipple, *Municipal Lighting*. Detroit, 1888, p. 157;104.

29. Ibid.

30. Garber, Megan. "Tower of Light: When Electricity Was New, People Used It to Mimic the Moon." In: The Atlantic. Atlantic Media Company, March 6, 2013. Accessed August 2, 2019. https://www.theatlantic.com/technology/archive/2013/03/tower-of-light-when-electricity-was-new-people-used-it-to-mimic-the-moon/273445/.

31. Ibid.

32. Societe des ingenieurs civils de France. *Memoires et compte rendu des travaux*. 1885, Vol. 1, p. 73.

33. Schivelbusch, Wolfgang. Op. cit. p.128

34. Since 1999, the Eiffel Tower has a rotational beacon that reaches 80 km of distance. The light performs a decorative version of the function of a lighthouse. In: https://www.toureiffel.paris/

35. Nye, David E. Op. cit. P 32, 33.

36. Everything manipulated by people can be considered artificial.

The simple act of reflecting sunlight and bringing light where there was none is an artifice.

37. Hoyos, B. D. *Mastering the West: Rome and Carthage at War.* New York: Oxford University Press, 2017. p. 160.

38. Heath,T.L. *The Works of Archimedes.* Cambridge University Press, 1897. On the sphere and the cylinder volume 1 and 2.

39. Ways of spaceflight translated from the German: Wege zur Raumschiffahrt.

40. Oberth, Hermann. *Ways to Spaceflight (Wege zur Raumschiffahr).* National Aeronautics and Space Administration, Washington, 1972. p. 478.

41. Ibid. p. 478

42. Redd, Nola Taylor. "Hermann Oberth: German Father of Rocketry." Space.com. Space, March 5, 2013. Accessed August 18, 2019. https://www.space.com/20063-hermann-oberth.html.

43. The Stone from the Moon is a science fiction novel by by Otto Willi Gail 1930. In: Gail, Otto Willi. *The Stone from the Moon*. New York: Stellar Pub., 1930.

44. Ibid.

45. Hoberman, J. "When Fritz Lang Shot the Moon." The New York Times. The New York Times, Accessed June 27, 2019. https://www.nytimes.com/2019/06/27/arts/fritz-lang-woman-in-the-moon.html.

46. Oberth, Hermann. Op. cit. p. v.

47. Chaubin Frédéric, and Simone Philippi. *Cosmic Communist Constructions: Photographed.* Köln: Taschen, 2011. p. 11.

48. Hermann Oberth thought of Tibet as an inaccessible territory where the satellite could photograph the place and its people.

49. Oberth mentions the possibility of having prevented the disaste of the Titanic in 1912 In: Oberth, Hermann. Op. cit. Chapter 20. p. 480.

50. Oberth's intention was to have a "cold zone" for the protection of nature" Ibid. Chapter 20 p. 500.

51. Ibid Chapter 13 page 279.

52. Redd, Nola Taylor. Op. cit.

53. "*The German Space Mirror*." LIFE, July 23, 1945.

54. Buckingham, A. G.; and Watson, H. M.: *The Uses of Orbiting Reflector Satellites*. Preprint 67-118, American Astronaut. Soc., May 1967.

55. The Vietnam war happened during the Cold War (1947-1991).

56. *Ehricke, Krafft A.: Space Light: Space Industrial Enhancement of the Solar.* Option. Acta Astronaut., vol. 6, no. 12, Dec. 1979, p. 1515-1633.

57. Freeman, Marsha, and Krafft A. Ehricke. Krafft Ehrickes Extraterrestrial Imperative. Burlington, Ontario: Apogee Books, 2008.

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60. Before the invention of electric light, the spotlights were a combination of a flame and a concave reflector which projected the light on one direction. In: Schivelbusch, Wolfgang. Op. cit. p. 196

61. Moholy-Nagy László. *The New Vision and Abstract of an Artist. New York:* Wittenborn, 1967. p. 35.

62. Ibid. p. 6.

63. Ibid. p. 50.

64. Ibid. p. 76.

65. Raspopina, Sasha. "Cult of the Cosmic: How Space Travel Became the Unofficial Religion of the USSR." The Calvert Journal. Accessed October 7, 2019. https://www.calvertjournal.com/features/show/4645/space-propaganda-posters-songs-soviet-religion.

66. “Regatta-Consortium.” space. Accessed August 7, 2019. http://www.old.space-regatta.ru/page_30e.htm.

67. The term “Cold War” is attributed to Bernard Baruch, an American financier and presidential advisor who used the term to name the geopolitical tensions between the USSR and the United States.

68. “The Kitchen Debate - Transcript.” Accessed August 20, 2019. https://www.cia.gov/library/readingroom/docs/1959-07-24.pdf.

69. The Space Race lasted from 1955 to 1975. .

70. The Calvert Journal is a publication for culture, innovation, photography and travel in the New East. Raspopina, Sasha. Op. cit.

71. Ibid.

72. Ibid.

73. Gerovitch, Slava. *Soviet Space Mythologies: Public Images, Private Memories, and the Making of a Cultural Identity.* Pittsburgh, University of Pittsburgh Press, 2015. p XVIII

74. Ibid. p 162.

75. Ibid. p 156

76. Powell, Nick. *The Effect of Glasnost on the Dissolution of the Soviet Union,* June 29, 2011, 1–15. Accessed August 4, 2019. http://wordscapes.com/nick/bio/TCR_22_3_Spr_POWELL.pdf.

77. The main justification for the developing of Znamya was that it could become a source of illumination and solar energy.

78. Epo Energia was founded by S. P. Korolev and it was considered the soul of the Soviet space program. Their activities included long-range ballistic missiles and space rocketry.

79. Leary, Warren E. “Russians to Test Space Mirror As Giant Night Light for Earth.” The New York Times. The New York Times, January 12, 1993. Accessed August 27 https://www.nytimes.com/1993/01/12/science/russians-to-test-space-mirror-as-giant-night-light-for-earth.html.

80. MIR (1986- 2001) was the Russian space station orbiting the earth.

81. The commercial name for the film is Mylar, a material used for its durability, its high levels of reflection and its extremely light weight (with a thickness of 4 nanometers, it is so thin that the weight of one square meter weighs only five grams).

82. Сыромятников, В. С. 100 Рассказов о Стыковке и о Других Приключениях в Космосе и На Земле. Москва: Логос, 2010. (Syromyatnikov, B. C. *100 Tales of Docking and Other Adventures in Space and on Earth.* Moscow: Logos, 2010.) p 283.

83. The Space Regata consortium was the organisation founded in 1990 for the developing of the Znamya Satellite.

84. Gerovitch, Slava. *Soviet Space Mythologies: Public Images, Private Memories, and the Making of a Cultural Identity*. Pittsburgh, University of Pittsburgh Press, 2015. p XI

85.Ibid. p XI

86. Beech, Martin. *Terraforming: the Creating of Habitable Worlds.* Regina, Canada, Springer. 2016. p.7.

87. Planetary scientist Joel Levine: Levine, Joel S. *“Terraforming Earth and Mars.” Mars: Past, Present, and Future*, January 1, 1992, 17–26. Accessed October 2. https://doi.org/10.2514/5.9781600866173.0017.0026.

88. Bratton H. Benjamin: *The Terraforming,* 2019 Strelka Press. p.9.

89. For the USSR, Kazakhstan was one of the main suppliers of wheat.

90. There is no explicit information on any reliable source (such as the Space Regatta Consortium website or the memories of V. Syromyatnikov) about Znamya, confirming that the satellite was also planned for military purposes. However, regarding all the previous studies about the space reflector the military potential of the technology is already latent

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by
Pau Saiz Soler